Using complexity and volatility characteristics to guide hybrid project management

Journal Item

Using complexity and volatility characteristics to guide hybrid project management

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Abstract

Purpose: The paper aims to provide methodological support for hybrid project management, in which the discipline of predictive methodologies combines with the flexibility of adaptive ones. Specifically, the paper explores the extent to which complexity and volatility dimensions of organisational problems inform choices of PM methodologies both theoretically and in current practice, as a first step towards better methodological support for hybridisation.

Design/methodology/approach: The paper takes a mixed method approach, including both an in-depth analysis of the literature and primary research with practitioners. Primary research consists of a small scale survey ($n = 31$) followed by semi-structured interviews, with findings triangulated against evidence from the literature review.

Findings: The paper provides empirical insights on how complexity and volatility of organisational problems can inform hybrid project management practices. Specifically, it suggests a mapping between volatility and complexity dimensions, and predictive and adaptive risk controls, systematising hybrid combinations in projects.

Research limitations/implications: Due to the small participant sample, the research results may lack generalisability.

Practical implications: The paper includes implications for the development of methodological support for setting up hybrid projects in practice.

Originality/value: The paper addresses a gap acknowledged both in the literature and by practitioners.

Keywords: Project management, hybrid methodologies, complexity, volatility, problem solving

Article Type: Research paper

1 Introduction

The Project Management Institute (PMI), an international professional body for project management (Carton et al., 2008), sees projects as the instruments used by organisations to "help meet their strategic goals like meeting changes in market demands, customer requests, or organisational requirements and in this way adapt to the changing business environments" (Project Management Institute, 2013).

With increasing pressures on organisations to become more flexible and to explore new technologies and operational domains, the problems faced become more complex and volatile, so that existing Project Management (PM) methodologies and practices are increasingly challenged, with project deviation or failure common. For instance, a study reported in Böhle et al. (2015) into 5,400 Information Systems projects, an important class of organisational project, concluded that 50% of them either exceeded their planned budget before completion or addressed a reduced scope, while 20% even put the existence of the company at risk. Moreover, while project success appears to be increasing (PMI, 2017), mainly due to better organisational maturity, performance across different organisations remains patchy. Some authors have proposed that project management should be regarded as a form of organisational problem solving (Ahern et al., 2014), with practitioners looking at novel ways to combine known approaches and practices into hybrid methodologies (Theocharis et al., 2015) better suited to the nature of today's organisational problems.

This is the view considered by our research, which explores PM as problem solving with a focus on the extent to which characteristics of organisational problems can inform choices of PM methodologies and practices, and may lead to more successful ways to set up and manage projects. In our work, we are not industry specific and, instead, consider common traits of organisational problems and their influence on projects.

1.1 Background

The PMI defines a project as "a temporary endeavor undertaken to create a unique product, service or result," with project management "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements" (Project Management Institute, 2013).

Budget, schedule and output quality have been the most commonly applied criteria to measure project success for decades (Atkinson, 1999), further qualified into process and product performance (Barki et al., 2001; Nidumolu, 1996; Ropponen and Lyytinen, 2000; Faraj and Sproull, 2000): *process performance* relates to project efficiency and is measured by adherence to budget and schedule (Nidumolu, 1996; Wallace and Keil, 2004), while *product performance* relates to the project outcome, a.k.a. *scope*, and its quality in terms of realised stakeholders' benefits (Barki et al., 2001; Nidumolu, 1996; PMI, 2017).

Project success is affected by *project risk*, defined by the PMI as "an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more projects objectives" (Project Management Institute, 2013). Project risk has its origins in the uncertainty present in all projects, with *risk management* aimed at decreasing the likelihood or impact of negative events in a project (Project Management Institute, 2013). Risk management includes three basic processes: *risk identification*, which consists of recognising and documenting risks; *risk analysis*, which examines each risk in order to assess its likelihood and impact; and *risk treatment* (Purdy, 2010), which devises strategies to reduce either likelihood (*risk prevention*) or negative impact (*risk adaptation*) (Fan et al., 2008). Risk prevention usually applies at the project planning stage, while adaptation applies whenever prevention is not possible (Royer, 2000; Miller and Lessard, 2001; Fan et al., 2008). Risk treatment involves the introduction or improvement of controls, where a *control* is a measure – process, policy, device or other actions – aimed at lowering risk (Aven, 2011). Its effectiveness will depend on the degree of influence the project team has on the risk, i.e., its *controllability*.

Project risk impact is typically measured in monetary terms, but not all risk can be estimated up-front, so that some authors (e.g., Gemino et al. (2007)) have classified risk depending on whether it can be identified before or after project start, with an acknowledgement that project risk tends to decrease as a project unfolds as uncertainty diminishes and the actual project performance becomes more evident.

While uncertainty is often equated with risk, there are important differences. From a PM perspective, risks must be identifiable via the threats they embody, and quantified in terms of the likelihood and severity of their consequences (Cleden, 2017). This is not always possible with uncertainty. More precisely, and by taking a knowledge-centric view, Cleden (2017) observes that all projects start with inherent uncertainty and an important part of PM and its risk analysis is to transform such uncertainty by separating risk (*known unknowns*) from knowledge (*known knowns*) and untapped knowledge (*unknown knowns*), until what all that is left are the unpredictable events and knowledge gaps we may not be aware of (*unknown unknowns*). This latent uncertainty is "unfathomable" (Cleden, 2017), either because we do not know it exists or because we have no way to assess or understand it. Dealing with uncertainty requires different strategies beyond traditional risk management, such as experimentation and the continuous generation of knowledge throughout the project lifecycle (Ahern et al., 2014): in particular, fast iterations of learning may reduce areas of uncertainty and allow the project to react quickly to emerging issues, assuming the project is sufficiently adaptive (Cleden, 2017; Costantini et al., 2017).

A *project management methodology* is defined by the PMI as a set of methods, techniques, procedures, rules, templates and best practices used on a project (Project Management Institute, 2013). Since the 50s, PM methodologies have been defined to ensure robustness and applicability to a wide range of projects, with different methodologies leading to different PM processes. Specifically, while the PMI expects that any PM process should comprise the five distinct *process groups* of Initiating, Planning, Executing, Monitoring & Controlling, and Closing, their order will vary depending on the methodology applied. Early methodological approaches were mainly *predictive*, that is rational and normative, aimed at making it easy to devise and follow the project plan without deviations (Špundak, 2014). They were characterised by up-front planning, tightly controlled processes and activities and explicit documentation, and emphasised process predictability, maturity and repeatability, so that solutions could be delivered in compliance with external quality standards (Boehm and Turner, 2004). Predictive methodologies favour sequential delivery, with process groups following a logical sequence of work: the classic *Waterfall* (Royce et al., 1970) is a well-known example. In the 70s, however, particularly in the context of software development, PM approaches started to evolve, leading to new iterative and incremental methodologies (Larman and Basili, 2003), whose basic idea was that a product should be developed iteratively, with subsequent increments, allowing the developer to learn from previous iterations (Basili and Turner, 1975) and make small adjustments throughout the project. A notable example is Boehm's *spiral model*, where at each iteration in the spiral, risk is identified and resolved. In the 90s, still mainly in the context of software development, several new *adaptive* approaches started to appear, such as *Agile* (Fowler et al., 2001) or *Lean* (inspired by Toyota lean manufacturin (Ohno, 1988)): at their core was a desire to embrace rather than control change (Špundak, 2014). They emphasise emergent knowledge (Bider, 2014) and continuous adaptation to change via light-weight processes made of fast and frequent iterations, with high reliance on tacit knowledge, high performing project teams and verbal communication, and with solution quality being equated to the value delivered to the customer who is expected to have a close relationship with the delivery team throughout the project (Boehm and Turner, 2004). Adaptive PM methodologies have now become popular well beyond software development (Highsmith, 2009; Cobb, 2011) and are widely applied alongside, and often combined with, predictive ones. According to a the PMI's 2017 'pulse' survey (PMI, 2017), 71% of the surveyed professionals ($n = 3,234$) adopted adaptive approaches for their projects either sometimes (31%), often (29%) or always (11%), against 29% reporting rarely (17%) or never (12%).

The correlation between project success and choice of methodology has been evidenced in the literature. For instance, based on a large-scale survey, Joslin and Müller (2015) estimated that the application of a PM methodology accounts for 22.3% of the variation in project success, when measured against the overall project objectives, while a study reported in Tiwana and Keil (2004) indicated that the choice of methodology was the most critical risk factor in software projects.

Different methodologies are differently suited to different organisational problems, as their delivery model impacts how risk and uncertainty are handled (Cleden, 2017). In predictive methodologies, delivery is organised in fully planned stages, with gateways between them to maintain control and prevent 'spillovers' from one stage to the next, with the assumption that scope, schedule and budget are fixed and entirely predicted from the start. Instead, in adaptive methodologies, delivery is based on iterative cycles in which retrospective reviews are used to learn lessons from one release cycle to the next, so that scope, schedule and budget can be adjusted as the project unfolds. In other words, the former assume stability and predictability from the start, while the latter can cope with a dynamic environment where many factors may change.

Organisational culture also influences methodological choices, as being adaptive requires the relinquishing of central control in favour of power distribution and team self-organisation (Boehm and Turner, 2004), something not required by predictive methodologies. In fact, adaptive methodologies are known to rely on tacit knowledge, high performing teams and verbal communication (Bider, 2014). On the other hand, external compliance and management preference often favour process predictability, maturity and repeatability by means of predictive PM tools (West et al., 2011). Also coordination challenges resulting from complexity are seen as better dealt with by the planning, coordination and control provided by predictive methodologies (Baccarini, 1996*a*).

From a knowledge perspective, Conklin (2006) describes predictive methodologies as "a picture of already knowing," and adaptive ones as "a picture of learning," with the assumption that the more novel the problem or its solution, the more the problem solving involves learning. In particular, Ahern et al. (2014) identifies different modes of problem solving based on level and pace of knowledge change, as well as the type of risk or uncertainty involved. According to them, complex problem solving, as occurs in today's organisations, is one characterised by high levels of knowledge change at a pace that can be very high, and with uncertainty that can only be estimated.

1.2 Research problem

Due to their characteristics, predictive and adaptive methodologies have long been seen as antithetic, each with its own "home ground" (Boehm and Turner, 2004): large, structurally complex systems and project teams in highly regulated industries with fairly stable requirements will use predictive methodologies; small systems and teams, in volatile environments and with readily available users and customers will use adaptive ones. However, the last decade has seen an increase in hybrid approaches, as project teams attempt to reap the benefits of combining the discipline of predictive methodologies with the flexibility of the adaptive ones, better to deal with characteristics of today's organisational problems.

Yet, understanding of hybrid PM approaches and their adoption remains limited, with few studies focussed primarily on software product development. For instance, according to Vijayasarathy and Butler (2016), software development approaches are chosen based on organisation size, criticality and size of project, and size and number of teams involved, with hybrid approaches being preferred by small teams and for projects of medium budget and high criticality, regardless of organisation size. This is in contrast with predictive approaches favoured by large organisations with large teams on high budget and high criticality projects. Theocharis et al. (2015) postulates that the use of hybrid methods is mainly due to the reluctance of management to embrace adaptive methods fully, also echoing West et al. (2011), whose findings indicated that the adoption of adaptive approaches is constrained by organisational culture and decades of predictive practices. The latter also envisaged that PM processes would become less about a particular method and more about "applying the right mix of practices and techniques to the situation and problem." Along these lines, Adelakun et al. (2017) investigated practices within the IBM Centre of Excellence in Chicago, US, observing emerging PM hybrids characterised by loose planning, but extensive coordination with PM serving as gatekeeper, and, in terms of scope management, loosely defined constraints at project start, but continuous monitoring and some adaptation throughout the process to avoid customer dissatisfaction or contract violation. In those projects, they observed that documentation remained an integral part, but its formality or frequency was project dependent. Also, while continuous feedback was regularly elicited from the customer, it fell short of direct involvement, with project teams not fully self-organised and managed, but empowered within a hierarchical organisational structure.

Beyond these studies, we found no research on how practitioners choose and adapt project methodologies and practices on a project by project basis and in relation to specific characteristics of their organisational problems, which is the overarching aim of our work. In this paper, we address the following questions:

- which characteristics of organisational problems influence PM practices?
- in which ways do different PM practices and their integration help mitigate risk and uncertainty related to those characteristics?

We will address these questions via a mixed method approach, including both an in-depth analysis of the literature (Section 2) and primary research (Section 3). We will draw our findings together in Section 4 and conclude the paper in Section 5.

2 Analysis of the literature: factors driving PM choices

2.1 Characteristics of organisational problems

In the early 70s, Rittel and Webber (1973)'s seminal work in the context of social policy started to question the applicability of traditional problem solving and planning approaches from the industrial age, focused on notions of efficiency and optimisation, and fully planned rational processes. They introduced the notion of *wicked problem* as one that is essentially unique, cannot be easily defined, dependent on differing stakeholders' perspectives, defying any single notion of solution, with no definable "stopping rules" (Rittel and Webber, 1973) for the problem solving process, whose requirements, constraints and resources change over time, and whose solution, assuming one such exists, is a "one-shot operation," i.e., there is no scope for trial and error, as the effects of any intervention are irreversible. Over the following decades, the concept became more and more influential in management science and beyond, applied in many domains whose problems exhibit such characteristics. While not necessarily wicked, today's organisational problems exhibit many wicked characteristics which make upfront planning in projects very challenging, somewhat explaining the rise in popularity of adaptive approaches. In particular, within the PM literature, much attention has been paid to notions of complexity and volatility in organisational problems, which we consider next.

2.2 Complexity

Complexity has been explored extensively and many definitions exist, with various authors attempting to synthesise some unified understanding. Based on a comprehensive survey Geraldi et al. (2011), for instance, proposes five characterisations of complexity, as follows. The first, with roots in the work of Williams (1999) and Baccarini

(1996*b*), is *structural* complexity, related to the existence of a large number of distinct and interdependent elements. Next is *uncertainty*, also from Williams (1999), related to a number of factors, including risk, lack of information or knowledge, presence of ambiguity, lack of agreement, etc. Then comes *dynamics*, related to changes in goals, product specifications, management team or the environmental context, followed by *pace*, related to time-criticality of goals. Finally *socio-political* complexity relates to conflicting stakeholders' interests and difficult personalities. In the context of complex engineering projects, Bosch-Rekveldt et al. (2011) also consider *environmental* complexity, in this case covering both geophysical elements, like weather conditions, market influences, like competition, and political influences.

According to Baccarini (1996*b*), two common meanings of the term complexity are conflated in project complexity: structural complexity, mentioned above, as being related to many varied interrelated parts, and the characteristics of being "complicated, involved, intricate". Indeed, Geraldi et al. (2011)'s various characterisations relate to both. The distinction between complex and complicated is also made by other authors, for instance, Whitty and Maylor (2009), who take a complex system view of projects, so that a complex project is seen as one exhibiting emergent behaviour that cannot be inferred from its components, while a complicated project is one which is "intricate, involved, tangled, and knotty."

Structural complexity is by far the most common notion in the literature. Further qualifications follow two lines of thought: one related to the organisational structure and the social environment of a project, and the other to the technical complexity of tasks to be performed in the project. Along these lines, Conklin (2006) differentiates between *social complexity*, which relates to the number and diversity of stakeholders involved, and *technical complexity*, based on the number of technologies involved and the number of possible interactions among them, although this notion also includes the rate of technical change. Similarly, Baccarini (1996*b*); Tiwana and Keil (2004) differentiate between *organisational complexity* rooted in the number of different organisational parts and their interdependence, and *technological complexity*, related to materials, production processes and technological knowledge required.

Ahern et al. (2014) focus on *knowledge complexity* in a wider sense, related to the fact that in complex projects not all that is relevant is completely known at the outset, as predictive PM methods would assume in their front-end project planning. Instead, they see complex project management as a form of complex problem organisational solving which continuously creates contextually emergent knowledge, which is distributed, untapped and even tacit. A similar perspective is expressed by Tiwana and Keil (2004) in the context of software projects, seen as a process of "embodying technical knowledge and knowledge of customer needs into a coherent [software] solution."

From our analysis of the literature, we define *complexity* as related to the presence of many interconnected parts, which may interact in complicated or unpredictable ways. This definition is closely aligned with structural complexity (Geraldi et al., 2011) in the literature. Moreover, we further qualify complexity along the dimensions of *social*, when related to people and their norms and cultural aspects, *technical*, when related to systems, structures and technologies, and *knowledge*, when related to what is known in the form of distributed, tacit, codified and non-codified knowledge. Table 1 indicates how our chosen definitions relate to those we found in the literature. It is worth noting that such dimensions are not necessarily independent: in particular, knowledge complexity is often the result of social or technical complexity.

Table 1: Complexity: relation to the literature reviewed

Social	**Technical**	**Knowledge**
social (Conklin, 2006); socio-political (conflicting stakeholders' interest and difficult personalities); uncertainty (lack of agreement) (Geraldi et al., 2011); environmental (political influences) (Bosch-Rekveldt et al., 2011); organisational (Baccarini, 1996*b*; Tiwana and Keil, 2004)	technical (Conklin, 2006); environmental (geophysical characteristics) (Bosch-Rekveldt et al., 2011); technological (materials and processes) (Baccarini, 1996*b*; Tiwana and Keil, 2004)	knowledge (Ahern et al., 2014); knowledge of customer need (Tiwana and Keil, 2004); environmental (market influences) (Bosch-Rekveldt et al., 2011); technological (knowledge) (Baccarini, 1996*b*; Tiwana and Keil, 2004)

It is also worth noticing how often in the literature uncertainty, dynamics and time-criticality are considered dimensions of complexity, while we associate them with volatility, which we discuss next.

2.3 Volatility

In its common meaning, volatility relates to a propensity to change, often rapidly and unpredictably. As discussed in the previous section, notions of dynamics, time-criticality or pace of technological change are often conflated with complexity in the literature, while other authors (Sauer et al., 2007) have used the term volatility to indicate any change in a project, whether of governance, e.g., project manager or sponsor, or of target, e.g., schedule, budget or scope.

In the system thinking tradition (Richardson, 2011), a distinction is made between endogenous, i.e., from within the system and often arising from its complexity, and exogenous change, i.e., driven from the external environment. As we will see, both can be present in projects, leading to different risks and risk responses.

In the software PM literature, volatility is often associated with requirements (Nurmuliani et al., 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004), but this can be seen as an instance of Geraldi et al. (2011)'s more general notion of dynamics.

We argue that conflating complexity and volatility is problematic, as the risks arising from volatility are quite distinct from those arising from complexity: for instance, Gemino et al. (2007) argue that risks related to complexity are potentially knowable at the start of a project, so that traditional risk management largely applies, while Ward and Chapman (2003) observes that risks from volatility are by and large unknowable at the start and emerge during the project, requiring an approach more focused on uncertainty than traditional risk management. We agree with this assessment, taking the view that volatility should be considered separately from complexity, and see the above examples as manifestations of volatility.

Analogue to complexity, our literature analysis has highlighted the lack of a definitive notion of volatility. Therefore, in our work we define *volatility* as related to the likelihood of change, further qualified along the dimensions of social, technical and knowledge, as per complexity. Similarly, these dimensions are not independent, with knowledge volatility often being the result of the other two. Table 2 relates our definitions to the literature.

Table 2: Volatility: relation to the literature reviewed

Social	**Technical**	**Knowledge**
volatility (target, governance) (Sauer et al., 2007); volatility (requirements) (Nurmuliani et al., 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004); dynamics (change in management team or environmental context) (Geraldi et al., 2011)	technical (rate of technical change) (Conklin, 2006); volatility (target) (Sauer et al., 2007); volatility (requirements) (Nurmuliani et al., 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004); dynamics (change in product specifications) (Geraldi et al., 2011)	volatility (requirements) (Nurmuliani et al., 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004); dynamics (change in environmental context) (Geraldi et al., 2011)

2.4 Complexity and volatility factors

There is agreement in the literature that understanding complexity and volatility is important in PM (Baccarini, 1996*b*; Remington and Zolin, 2009), as they affect project planning and outcomes (Baccarini, 1996*b*). Hence, practitioners must be able to assess the level of complexity and volatility they are dealing with to inform key stakeholders and take appropriate PM decisions (Remington and Zolin, 2009). To this end, ways to assess complexity or volatility and their impact on projects are needed (Remington and Zolin, 2009).

Few authors have proposed approaches to help practitioners make such an assessment early on in a project lifecycle and in specific industries. For instance, Bosch-Rekveldt et al. (2011) propose a framework for project complexity in large engineering projects, which includes a wide range of factors for consideration, extracted from the literature and practitioner interviews, and classified under technical, organisational or environmental complexity. Similarly, Clarke and O'Connor (2012) propose a framework for software development projects, including technical and non-technical factors also extracted from the literature. Still in the context of software development, Kalus and Kuhrmann (2013) go a step further by proposing both a comprehensive checklist covering elements of complexity from the literature, and matching them with suggested desirable software development practices, while Fitsilis (2009) proposes a framework for measuring software project complexity based on uncertainty, knowledge complexity, and interactions arising from social complexity. Further examples of industry specific measurements can be found in Lu et al. (2015), which introduces a model developed from the Shanghai World Expo construction project to measure project complexity in large-scale projects from task and organisation perspectives, and in He et al. (2015), which deals with complexity of mega construction projects in China.

In our work, we are not industry specific and have synthesised a collection of factors from the literature which are general enough to be relevant across a wide range of projects. These are summarised in Table 3, with reference to our definitions of complexity and volatility and their dimensions. Some factors can be easily associated with specific dimensions. For instance, a large numbers of stakeholders or organisational units involved and diversity of stakeholders are, almost by definition, manifestations of social complexity, while a large number of technologies or interfaces involved, of technical complexity: these factors were identified, particularly, in the work of Baccarini (1996*b*), Williams (1999) and Fitsilis (2009). Similarly, tacit knowledge, distributed throughout an organisation, as indicated by (Ahern et al., 2014), is a clear manifestation of knowledge complexity.

Other factors may relate to more than one dimension. For instance, complicated communication due to organisational or technical characteristics, as identified by Lu et al. (2015), relate to both social and technical complexity. Similarly, uncertainty of goals, unclear meanings or stakeholders' hidden agendas can be associated with both social complexity (Saynisch, 2010; Williams, 1999), and knowledge complexity.

In terms of volatility, changing organisation, technology or context are mentioned by several authors (Whitty and Maylor, 2009; Conklin, 2006; He et al., 2015; Lu et al., 2015) and relate to social, technical and knowledge volatility, with uniqueness or novelty of the project task or target technology (Geraldi and Adlbrecht, 2007) relating both to knowledge complexity and volatility, and to technical volatility.

On the other hand, the time criticality of goals is seen by Geraldi et al. (2011) as a response to change in a general sense, i.e., in the organisation, technology or context: hence, it relates to both social and technical volatility.

That factors can be associated with more than one dimension is the result of their systemic relationships: organisational problems mostly concern socio-technical systems, in which a clear distinction along each of the dimensions is not always possible, with knowledge complexity often the result of technical or social complexity. Also, there is a degree of subjective interpretation in their definitions. Nevertheless, being able to disentangle the different dimensions may be a way to get a better handle on the different emerging risks and of ways to mitigate them via the application of specific combinations of PM controls and practices, which is the overarching aim of our research and the approach taken in this work.

2.5 Risk from complexity and volatility

As indicated in Section 1.1, project risk affects project success, the latter measured in process performance (budget and schedule) and product performance (scope and quality). In this section we consider project risk arising from complexity and volatility. A summary of our analysis is given in Table 4.

Table 3: Complexity and volatility factors

Dimension	Factor	Source
Social Complexity	Large number of stakeholders or organisational units involved	Baccarini (2004); Williams (1999); Conklin (2006); Girmscheid and Brockmann (2008)
	Diversity of stakeholders	Girmscheid and Brockmann (2008); Conklin (2006)
	Uncertainty of goals, unclear meanings or stakeholders' hidden agenda	Saynisch (2010); Williams (1999)
	Complicated communication due to organisational or technical characteristics	Lu et al. (2015)
Technical Complexity	Large number of technologies or interfaces involved	Baccarini (2004); Williams (1999); Conklin (2006); Girmscheid and Brockmann (2008)
	Complicated communication due to organisational or technical characteristics	Lu et al. (2015)
Knowledge Complexity	Lack of knowledge at project start	Ahern et al. (2014); Geraldi and Adlbrecht (2007)
	Uncertainty of goals, unclear meanings or stakeholders' hidden agenda	Saynisch (2010); Williams (1999)
	Novelty or uniqueness of the technical solution	Geraldi and Adlbrecht (2007)
Social Volatility	Rate of change in the organisation	Whitty and Maylor (2009)
	Time criticality of goals	Geraldi et al. (2011)
Technical Volatility	Rate of change in the technical solution	Conklin (2006); Whitty and Maylor (2009)
	Novelty or uniqueness of the technical solution	Geraldi and Adlbrecht (2007)
	Time criticality of goals	Geraldi et al. (2011)
Knowledge Volatility	Rate of change in the external environment, such as laws and regulations	He et al. (2015); Lu et al. (2015)
	Rate of change in the organisation	Whitty and Maylor (2009)
	Rate of change in the technical solution	Conklin (2006); Whitty and Maylor (2009)
	Novelty or uniqueness of the technical solution	Geraldi and Adlbrecht (2007)

Under social complexity, many stakeholders will complicate communication, leading to an increase the number of interactions and level of coordination required (Tiwana and Keil, 2004), which will impact time and effort and may result either in project delays or budget increase. This may also lead to information fragmentation (Conklin, 2006), with diverse stakeholders holding different understandings of the problem, hence having multiple, possibly conflicting, objectives and hindering the clear identification of project goals. Moreover, failure to identify how different stakeholders are affected by the project raises the likelihood that some may attempt to stop, undermine or even sabotage it (Conklin, 2006).

Technical complexity, driven by the number and nature of technical components and interactions, may increase the difficulty of understanding systemic long-term behaviour and to plan development (Whitty and Maylor, 2009), thus affecting both process and product performance. Inappropriate planning would expose the project to feasibility, budget, and scheduling risks (Tiwana and Keil, 2004), leading to possible scope creep, and schedule and budget overruns (Schmidt et al., 2001).

Social volatility often leads to shifting requirements, with additional effort and expensive reworking needed in order to adapt the solution in progress to the continuous changes (Tiwana and Keil, 2004), and so does volatility in the external environment, which is particularly difficult, if not impossible, to control (Lu et al., 2015). On the other hand, technical volatility may increase the likelihood of solutions becoming quickly obsolete (Conklin, 2006) and, in extreme cases, having to be discarded so that all development effort is wasted. Volatility within the organisation or its environment may cause project goals to be no longer appropriate (Geraldi and Adlbrecht, 2007), which may lead to complete project failure either because the key stakeholders do not need the deliverables any longer, or because the project scope becomes obsolete or impossible to deliver.

Finally, when goals are time critical, there is a need to meet tighter project timeframes and the interdependence between project components may become even more critical (Williams, 1999), with small deviations from the plan causing unexpectedly large effects and greater overspend (Williams, 2005).

In relation to risk treatment, Gemino et al. (2007) note that risk arising from complexity tends to be known at project start, while that arising for volatility tends to emerge throughout the project lifecycle. As a consequence, there is a tendency to apply risk prevention (i.e., reducing likelihood) to complexity and risk adaptation (i.e., reducing negative impact) to volatility. Indeed, risk prevention sits more naturally with predictive methodologies, which focus on planning and control, while risk adaptation sits with adaptive methodologies, which use short iterations to make adjustments and minimise impact. Each approach has its own strengths and limitations, of course. For instance, predictive planning may not be possible if there is insufficient knowledge at the start, as might be the case if we are dealing with a new problem for which the solution is unknown. Equally, adaptive incremental delivery may not apply if the scope cannot be broken down in that fashion. Understanding when and how specific controls apply within projects is one of the objectives of this work, so that we will return to this topic in our discussion in Section 4.

Table 4: Complexity and volatility and their effect on project success

Factor	May lead to	Affected success measure(s)
Large number of stakeholders or organisational units involved	information fragmentation increased interaction and coordination effort	process performance (budget and schedule)
Diversity of stakeholders	multiple objectives differing problem understanding diverging or conflicting goals stakeholder resistance increased interaction and coordination effort	process performance (budget and schedule) product performance (scope and quality)
Complicated communication due to organisational or technical characteristics	information fragmentation increased interaction and coordination effort	process performance (budget and schedule)
Uncertainty of goals, unclear meanings or stakeholders' hidden agenda	multiple objectives differing problem understanding diverging or conflicting goals	product performance (scope and quality)
Large number of technologies or interfaces involved	reduced ability to predict behaviour or estimate effort	product performance (scope and quality)
Lack of knowledge at project start	information fragmentation reduced ability to predict behaviour or estimate effort	process performance (budget and schedule) product performance (scope and quality)
Novelty or uniqueness of the technical solution	reduced ability to estimate effort reduced ability to predict behaviour	process performance (budget and schedule) product performance (scope and quality)
Rate of change in the organisation	shifting requirements loss of alignment between project goals and environment characteristics solution reworking	process performance (budget and schedule) product performance (scope and quality)
Rate of change in the technical solution	technical solution becoming quickly obsolete solution reworking	process performance (budget and schedule) product performance (scope and quality)
Rate of change in the external environment, such as laws and regulation	loss of alignment between project goals and environment characteristics solution reworking	process performance (budget and schedule) product performance (scope and quality)
Time criticality of goals	increased interdependence and coordination effort between project components	process performance (budget and schedule)

3 Primary research: a view from practice

Our analysis of the literature has highlighted complexity and volatility dimensions and factors which may contribute to project risk and hence impact project success. Based on that analysis, we followed up with primary research in order to identify how they affect practitioners' choices of PM methodology and their application in projects. Moreover, in order to inform further research, we also investigated any difficulty practitioners may have in doing so, current methodological tools available to them and where gaps exist.

The research consisted of a practitioner survey followed by in-depth semi-structured interviews.

3.1 Survey

The aim of the survey was primarily to establish which factors affect practitioners' choices and test their alignment to what we have found in the literature, as well as to recruit participants for the follow-up interviews.

3.1.1 Procedures

A standard survey design methodology was followed (Oates, 2005; Fowler Jr, 2013). Data were collected via an online questionnaire aimed at project, program or portfolio managers from various industries, who had worked on complex projects over at least the previous three years. Several channels were used to reach potential participants, including professional networks and LinkedIn, where two articles were published to generate interest. Participation in the survey was entirely voluntary and anonymous, with the exception of those participants who volunteered for the follow-up interviews, who were asked to provide a contact email address. The Open University's ethical guidelines for participant consent and data protection were applied throughout.

The questionnaire comprised 13 questions, designed to avoid ambiguity and delivered in English to prevent translation bias (Fowler Jr, 2013). A mixture of multiple choice and open questions was used: closed questions for clearly structured topics to save respondents' time, improve reliability of the answers and simplify the evaluation process (Oates, 2005; Fowler Jr, 2013); open questions for topics where all possible answers could not be anticipated (Fowler Jr, 2013). An 'others' option was made available whenever appropriate. The questionnaire was tested before publication by three experienced project mangers who helped fine-tune its design.

Three areas were explored:

- Respondents' demographics, including years of work experience, current occupational role, country of work, size of organisation, known PM methodologies and PM certification held. This information was collected in order to investigate possible associations between these characteristics and the choice of PM methodology in their practice.
- Project types and characteristics, particularly in relation to complexity and volatility. This information was collected to investigate associations with the adopted PM methodologies.

- Factors influencing methodological choices. This information was collected to assess which factors explicitly affected methodological choices in practice, and in relation to what we found in the literature.

For the latter, prompts were provided and participants were asked to select the three most influential factors with respect to each of predictive, adaptive and hybrid methodologies, with open ended choices allowing them to name additional factors. The prompts provided included all the factors in Table 3, plus two more corresponding to the level of team expertise and to mandatory requirements, e.g. from the organisation's management or PM office, as these are known to be factors affecting methodological choices (see Section 1.1): they also helped us separate practices related to complexity and volatility of organisational problems from those due to contextual or cultural organisational influences. In the survey, we used the terms 'traditional' and 'agile' as synonyms of predictive and adaptive, while PM may signify either Project Manager or Project Management, depending on context.

3.1.2 Analysis of findings

We received 31 completed questionnaires out of a total of 35 started.

Participants The majority of respondents had at least 5 years' experience, and just over half had over 10 years' experience (Table 5). The majority were project managers, worked in large enterprises in European countries, particularly the United Kingdom and Germany (Table 6). One project manager had worked on software projects in enterprises of all sizes. The majority were familiar with predictive methodologies with just over a third also familiar with predictive ones (Table 7). All but one had certifications either as professional PM practitioners or on specific approaches or both.

Table 5: Participants' roles and experience

	ROLE								
EXPERIENCE	Project team member	Project manager	Senior Project Manager	Program manager	PMO Manager	Departmental Head	Enineering Manager	Consultant	Grand Total
less than 1 year								1	1
1 to 3 years		2							2
3 to 5 years	1	3							4
5 to 10 years		4		1	1			1	7
more than 10 years		7	2	5		1	1	1	17
Grand Total	1	16	2	6	1	1	1	3	31

Projects and methodologies There was a good spread of project types in the sample (Table 8), although over a third were information systems/software projects. Most projects were considered by the respondents either complex or both complex and volatile. Hybrid methodologies were predominantly applied in the latter (Table 9), followed by predictive ones.

Table 6: Participants' organisations and countries of practice

	COMPANY SIZE			
COUNTRY	Large: 250+ staff	Medium: 50 to 249 staff	Mix of all sizes	Grand Total
Germany	9	1	1	11
multi-national (EU and NA..	1			1
Nigeria	1			1
South Africa	1			1
Spain	1			1
United Kingdom	14			14
United States	2			2
Grand Total	29	1	1	31

Table 7: Participants' certifications and knowledge of PM methodologies

	KNOWN METHODOLOGIES				
CERTIFICATIONS	Traditional	Agile	Traditional and agile	None	Grand Total
Professional PM	3		1		4
Professional PM and traditional	2		3		5
Professional PM and agile			2		2
Traditional	5		2		7
Traditional and agile		1	3		4
None	5		1	3	9
Grand Total	15	1	12	3	31

Table 8: Project types and characteristics

	PROJECT CHARACTERISTICS			
PROJECT TYPES	Both complex and volatile	Mostly complex	Mostly volatile	Grand Total
Information Systems (Software) Projects	4	9		13
Administrative/Management Projects	2	2	1	5
Product and Service Development Projects	3	4		7
Strategic Change Projects	1	1		2
Mix of project types	3	1		4
Grand Total	13	17	1	31

Table 9: Methodology applied by project characteristics and types

		APPLIED METHODOLOGY		
PROJECT CHARACTERISTICS	PROJECT TYPES	AGILE	HYBRID	TRADITIONAL
Both complex and volatile	Information Systems (Software) Projects		2	2
	Administrative/Management Projects		1	1
	Product and Service Development Projects	1	2	
	Strategic Change Projects		1	
	Mix of project types		2	1
Mostly complex	Information Systems (Software) Projects		6	3
	Administrative/Management Projects		1	1
	Product and Service Development Projects			4
	Strategic Change Projects		1	
	Mix of project types		1	
Mostly volatile	Administrative/Management Projects			1

Hybrid approaches 16 respondents indicated they had applied a mix of approaches and were asked to provide a brief description of what they did. In seven cases, they described their approach as predictive with some adaptive components, citing organisational policy as the main reason for the prevalent predictive element: adaptive practices were adopted primarily for software/IT components or to address specific needs, such as fast-prototyping or encouraging self-sufficient teams.

In two cases, an adaptive approach had been tried, but practices had reverted to more predictive ones. In another case, the organisation was transitioning from predictive to adaptive, so different teams were applying different approaches.

In just three cases, the choice of methodology was seen as dependent on the scope of the project, or of elements of it, and on the stakeholders involved, and the choice made was based on the experience of the project manager.

Factors influencing methodological choices The mappings between factors and methodologies emerging from the survey are given in Figures 1 and 2, where the responses of participants who were subsequently interviewed (see Section 3.2) are indicated in orange. Alongside the factors used as prompts, few new factors were added by participants. Specifically, one participant related their choice of methodology to the variability or otherwise of project scope, budget and schedule: in their opinion, a variable scope with fixed budget/schedule called for an adaptive methodology, while a fixed scope with variable budget/schedule called for a predictive one, with hybrid used when a balance of the three was needed. Two other participants added high risk (either to the organisation or its customers) as a factor, in both cases leading to a choice of predictive approaches.

Looking at methodologies first (Figure 1), in the choice of predictive methodologies, organisational drivers – such as management preferences for tried-and-tested approaches – and external requirements – such as funding or compliance – were by far the most influential factors followed by the presence of a large number of stakeholders or organisational units involved in the project. The presence of a large number of technologies was also influential, but not

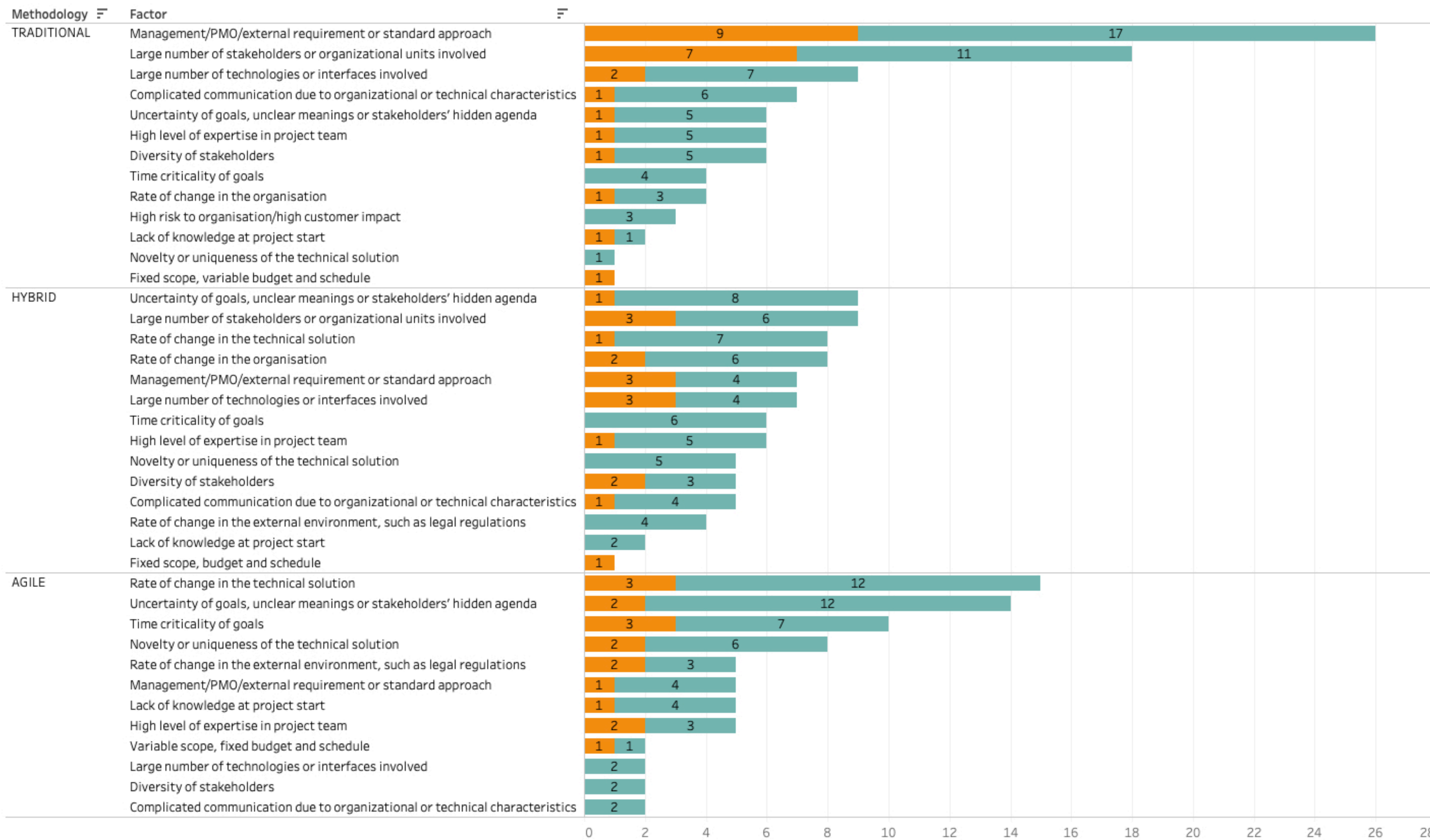

Figure 1: Most influential factors in the choice of each type of methodology, ranked by their frequency in participants' responses; orange indicates responses by participants subsequently interviewed

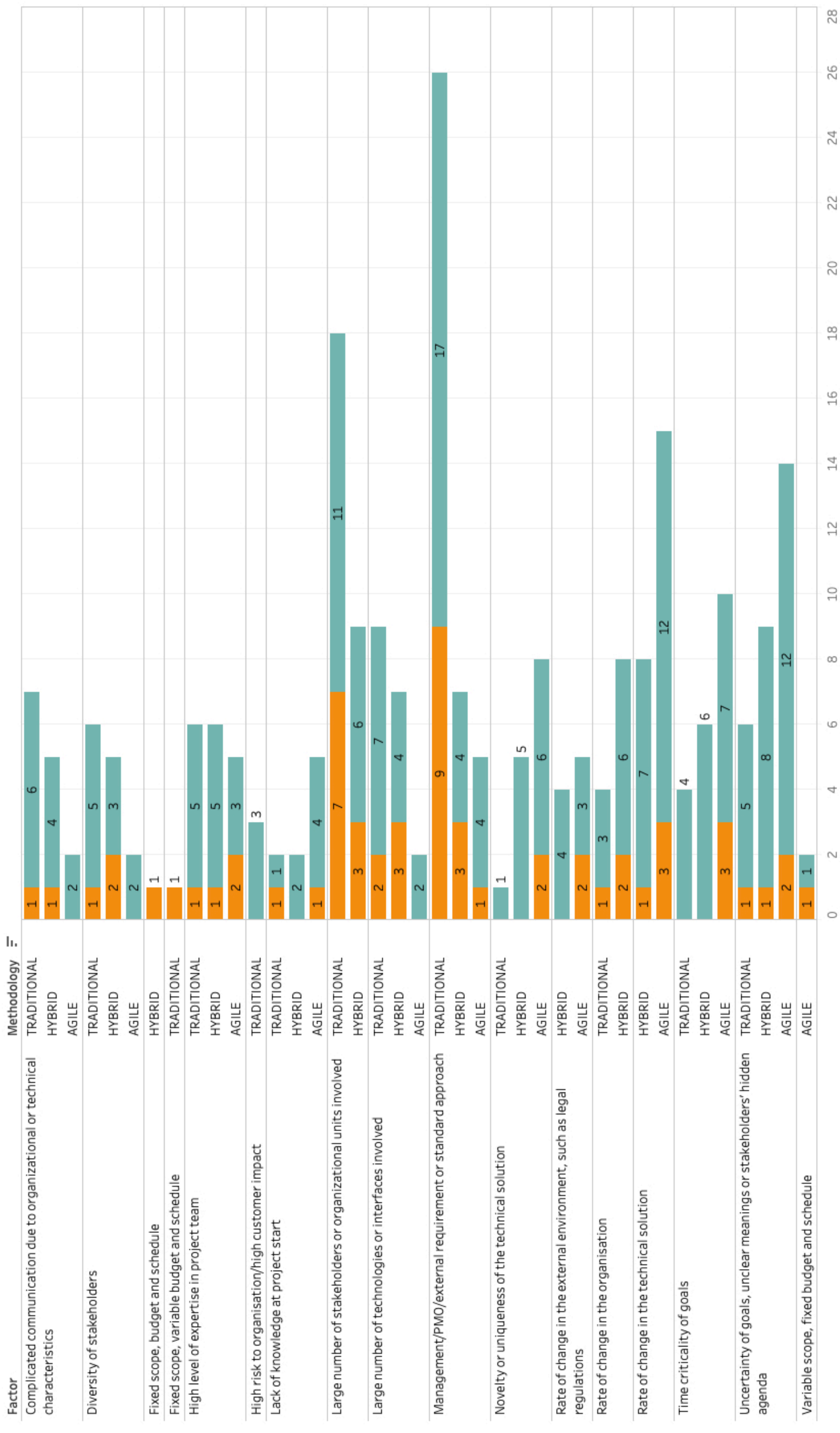

Figure 2: Methodology type associated with each factor, ranked by their frequency in participants' responses; orange indicates responses by participants subsequently interviewed

quite as the previous two factors. Therefore beyond organisational preferences, social and technical complexity appear to have a strong influence on the choice of predictive methodologies. In fact, the next influencing factor, complicated communication, is strongly related to both (see discussion in Section 1.1), which reinforces this observation.

For adaptive methodologies, the rate of change of the technical solution (technical volatility) and the uncertainty of goals (social and knowledge complexity) were the most influential factors, followed by the time criticality of goals.

Finally, in the hybrid case, we find influencing factors which combine social and knowledge complexity with technical and social volatility.

Looking at other factors (Figure 2), team expertise appears equally relevant in all choices of methodology, while diversity of stakeholders appears to require predictive or at least hybrid methodologies, although it should be noted that for our participants hybrid still meant some prevalence of the predictive element. On the other hand, factors related to knowledge complexity, e.g, lack of pre-given knowledge at start, novelty of the technical solution, etc., are more frequently associated with adaptive methodologies.

3.2 Interviews

While the survey helped us identify which factors affect practitioners' choices of PM methodology and the extent they relate to complexity and volatility, it fell short in providing insights into why that might be the case from a practitioner perspective and on how practitioners organise their projects in response, other than for a generic indication that in many cases hybrid approaches tend to embed adaptive elements within otherwise predictive methodologies. This was investigated in follow-up semi-structured interviews which also provided an insight into methodological tools currently used by practitioners in setting up their projects, and where gaps exist.

3.2.1 Procedures

The interviews were structured in four parts. The first part aimed at understanding the rationale for survey choices of factors against each of predictive, adaptive or hybrid PM methodology. The second part aimed at validating our definitions of complexity and volatility and their dimensions in relation to the participants' practice, including identifying real-world examples from specific projects. The third part focussed on specific PM practices adopted in projects as controls against risk arising from complexity and volatility factors. The final part addressed available methodological tool support and current gaps.

The interviews were conducted in person, over the phone or via Skype, depending on the interviewees' preferences, each lasting up to 40 mins. They were not recorded, but detailed notes were taken on which a subsequent thematic analysis was performed.

3.2.2 Analysis of findings

Ten out of the 31 survey participants volunteered for the interviews. Their demographics and project data are summarised in Figures 3 and 4: even in this smaller sample, there was a good spread of projects, experience and knowledge. Their choices of factors to methodologies are highlighted in orange in Figures 1 and 2.

	ROLE				
EXPERIENCE	Project manager	Senior Project Ma..	Program manager	Consultant	Grand Total
less than 1 year				1	1
1 to 3 years	1				1
3 to 5 years	1				1
5 to 10 years	1				1
more than 10 years	4	1	1		6
Grand Total	7	1	1	1	10

	COMPANY SIZE		
COUNTRY	Large: 250+ staff	Medium: 50 to 249 staff	Grand Total
Germany	4	1	5
multi-national (EU and NA..	1		1
United Kingdom	3		3
United States	1		1
Grand Total	9	1	10

	KNOWN METHODOLOGIES			
CERTIFICATIONS	Traditional	Traditional and agile	None	Grand Total
Professional PM	1			1
Professional PM and traditional	1	2		3
Professional PM and agile		1		1
Traditional		1		1
None	2	1	1	4
Grand Total	4	5	1	10

Figure 3: Interviewees' demographics

The following themes emerged from the interviews.

PROJECT TYPES	PROJECT CHARACTERISTICS Both complex and vol..	Mostly complex	Grand Total
Information Systems (Software) Projects	1	3	4
Administrative/Management Projects	1	2	3
Product and Service Development Projects	1		1
Strategic Change Projects		1	1
Mix of project types	1		1
Grand Total	4	6	10

PROJECT CHARACTERISTICS	PROJECT TYPES	APPLIED METHODOLOGY HYBRID	TRADITIONAL
Both complex and volatile	Information Systems (Software) Projects	1	
	Administrative/Management Projects		1
	Product and Service Development Projects	1	
	Mix of project types	1	
Mostly complex	Information Systems (Software) Projects	2	1
	Administrative/Management Projects	1	1
	Strategic Change Projects	1	

Figure 4: Interviewees' projects

Contextual factors For predictive approaches, organisational factors and external requirements were confirmed as highly influential, with many interviewees (Ids 22, 27, 30, 31 and 34) reporting the approach was dictated by their PM office. Some added that cultural and experiential factors matter stating that it is "difficult to swim against the stream" (Id 32) or that their organisation was very conservative and not ready for adaptive practices (Id 14). One interviewee (Id 8) saw it more pragmatically, in that they considered it better to adapt the project to the organisation than risking failure.

One interesting observation behind the adoption of hybrid approaches was in relation to the so-called 'driver pyramid' (Id 8) , described as "the higher in the organisation the more plan driven and longer term; the lower, the more adaptive and empowered to execute/act on shorter time scales."

Team expertise According to one interviewee (Id 30), "if you have a good team, methodology doesn't matter." However for predictive approaches, expertise was equated to working better, more quickly and cheaply (Ids 8, 30, 31), while for adaptive approaches was equated to having the right mindset (Id 27). One interviewee (Id 31) observed that in the case of low team expertise, they would choose an adaptive approach as the potential for damage would be lower.

Definition of complexity and volatility All interviewees agreed with our definitions of complexity and volatility, and their dimensions (Sections 2.2 and 2.3), and could relate their practical project experience to them.

One participant (Id 8), however, commented that complexity may also be an effect of the project time scale, as it is easier to see things clearly on short horizons. Similarly, some observed that volatility may well be the result of social complexity: the bigger the company, the greater the rate of change (Id 8), or the greater the number of stakeholders, the more likely the project scope and timeline will change (Id 31).

Complexity and volatility factors For predictive approaches, the presence of a large number of stakeholders or organisational units (social complexity) was chosen by most interviewees (Ids 3, 8, 14, 16, 22, 30, 31 and 34) as a determining factor, as it prevents the adaptive principle of a ‘single source of truth’ from being applicable and makes close physical collaboration, verbal communication and stand-ups impossible to achieve, particularly with people working in different time zones (Ids 3 and 8). Also, the presence of a large number of technologies or interfaces (i.e., technical complexity) (Id 30) or being in a stable environment (i.e., lack of volatility) (Id 3) were seen a good fit for predictive methodologies.

Generally, predictive approaches were regarded better than adaptive ones at controlling and managing risk, and in providing a long-term view (Id 3). An acknowledged strength was their ability to control change, which was seen by some as a good fit to deal with a high rate of change in the organisation (Id 16) and also to deal with the lack of a stable project team (Id 32), which is contrary to adaptive methodologies due to their expectation of team stability.

Instead, the need to learn as you go along, either due to the novelty or uniqueness of the technical solution or due to lack of sufficient knowledge at start, was a strong motivation for adopting adaptive methodologies (Ids 3 and 27). Similarly, adaptive methodologies were seen as more suited to goal uncertainty, as they require stakeholders to establish priorities early on and to validate both assumptions and outcomes quickly and often (Ids 3, 8 and 32). The establishment of priorities early on was also seen a good response to the time criticality of goals, as it steers towards delivering the most important things first (Id 32), alongside the speed of delivery resulting from concentrating resources to deliver more quickly (Id 3 and 32). Moreover, quick feedback loops were also seen as effective in the case of high rate of change in the technical solution (Ids 14 and 27).

Interestingly, while the (endogenous) rate of change in the organisation or project team was perceived as something in need of control, hence better handled by predictive approaches (Id 30), (exogenous) volatility in the external environment was deemed as requiring an adaptive approach (Id 27), due to the inability to control it.

Controls *Divide and conquer* was advocated by several participants to deal with complexity, with an understanding that any decomposition (of teams or tasks) has to be accompanied by clearly defined roles and responsibilities, stringent governance and accountability, and robust coordination and communication structures (Id 8, 14, 16 and 32). This was seen as particularly relevant in the case of regional teams, particularly when working across different time zones (Id 8). Careful planning was also advocated, including establishing preconditions for the start of each project phase (Ids 31 and 33), as well as breaking down the project in a way to minimise dependencies (Id 8). Careful documentation was also mentioned as an important control (Id 27).

Depending on the complexity dimension, different approaches were mentioned. For technical complexity, suggestions included a constant evaluation of requirements and realignment throughout implementation through short iterations (Ids 3 and 32), as well as using tried and tested solutions (e.g., known technology) wherever possible (Id 30). For knowledge complexity, establishing one ‘source of truth’ (Id 3) and communicating often and effectively (Id 30) were suggested. For social complexity, front-loading the project with as much detail and communication as possible was seen beneficial (Id 3), as well ensuring that stakeholders who influence and define success measures are kept informed throughout (Id 34).

Rapid and effective communication was also considered effective in the case of knowledge volatility (Id 30), as well as setting up small teams able to reach a common understanding in short iterative cycles (Id 8).

For volatility, interviewees advocated the need to identify early on areas for reviews which may require more interactivity with stakeholders and/or more adaptability (Id 27) in order to inform the overall project plan. For the latter, the advice included the separation of what can be done early and later (Id 31), to focus on short term incremental delivery and reconsidering requirements more often (Ids 8 and 32), and to “deal with the now, but keep looking ahead” (Id 27), so as to be ready for possible changes in direction. Putting in place some resilience support and ensuring senior management/leaders had the right “emotional intelligence” to deal with volatility were also seen important (Id 22).

Piloting, and using pilots as blueprints for the whole project (Id 8) was seen as effective when dealing with novel solutions, and generally knowledge complexity and volatility.

Finally, team expertise and the need to allocate people with the right experience and mindset to project teams was also seen as critical (Id 22).

Project nature and set up Project size was raised during the interviews with a preference for predictive in the case of large projects (Id 31) and adaptive for small ones (Id 30), while for technology projects a preference was expressed towards agility (Id 22).

Hybrid approaches were considered effective at programme level, with different projects using different methodologies (Id 22). For individual projects, one suggestion was to use a predictive approach to perform the stakeholder analysis and to structure the project overall, while identifying project elements where adaptive could be used to deliver increments more quickly or to deal with changing goals (Id 32). Also, within an overarching plan-driven framework, in which one tries to plan as much as possible to reach a certain level of commitment, a switch to adaptive methods was seen as a way to still deliver to the timeline when unforeseen events came into play (Id 3).

Methodological tools Many interviewees (Ids 14, 16, 27, 31, and 34) noted how they relied heavily on their experience and tried and tested practices, which they would adapt from project to project, and align with organisational culture.

Spending lots of time upfront understanding the problem and the organisation was deemed very important by relatively few (Ids 31 and 34) in order to parametrise each project, as well as talking to experts to validate their initial project architecture (Id 31).

Some used or adapted templates provided by their PM Office or developed in previous projects (Ids 30 and 34). Some common predictive tools were considered effective by many, in particular, the predictive way of analysing and managing stakeholders (Ids 22 and 32) and developing communication plans (Id 16) to deal with social complexity, and traditional risk management and control approaches, such as risk maps and quality gates (Ids 3, 22 and 34). For the estimation of technical complexity, function points (Id 3) and complexity points (Id 8) were mentioned.

Methodological gaps Despite the many PM tools available, gaps were perceived by all but one participant, who would welcome more methodological support at the very start of a project. In particular, there was a feeling that support for the whole front-end is lacking (Id 30) and that often practitioners are faced with a "black box" (Id 3) at the start. The "holy grail" (Id 27) would be an approach allowing practitioners to gather the information at the start needed to make a sound judgement on how to set up their project: something in which guidance and experience can come together. Of particular interest would be the ability to address the following problems:

- how to break down work packages effectively,
- how to eliminate peaks by fine-tuning iterations,
- how to estimate the effort needed to manage communication and alignment with stakeholders,
- how to decide when being adaptive is an option or a must.

4 Discussion

In this section, we bring together insights from our primary research and our literature review findings. We have seen how complexity and volatility may increase project risk and impact project success negatively, while PM methodologies provide the means to de-risk projects. Better to understand why and how that is the case, we have identified recurring complexity and volatility dimensions and factors, and analysed their effect on project risk. Similarly, we have investigated different controls offered by PM methodologies and how they may be deployed against those factors. Breaking down complexity and volatility into their prevalent dimensions and manifestations, and PM methodologies into their constituent controls has allowed us to investigate a finer-grain association between specific risk factors and methodological controls, resulting in the mapping captured in Figure 5, where for each factor, we have indicated the selection of suitable controls identified through our research, indexed by its associated methodology. For instance, under social complexity, risk derived from the diversity of stakeholders is often controlled in predictive methodologies via a combination of stakeholders management and well developed communication plans, including ensuring that key stakeholders are kept informed, while adaptive methodologies will favour their direct involvement in each development cycle, including setting priorities and reviews.

Looking at the distribution of controls against factors in the table, the following observations can be made.

The mapping reflects an acknowledgement that adaptive principles and practices are challenged by social complexity, due to their expectations of key stakeholders' continuous involvement in development and reviews, including their ability to agree common priorities early on, and their reliance on verbal communication and tacit knowledge within high performing teams. Instead, predictive approaches provide various well established controls to deal with social complexity, particularly through stakeholder management, stringent governance and accountability, and explicit communication plans, to help overcome coordination and communication challenges. Predictive methodologies also appear better equipped at dealing with social volatility than adaptive ones, including social volatility within the organisation and the project team: while adaptive methodologies rely on stable high performing teams and tacit knowledge, predictive methodologies make use of change control and explicit documentation to deal with social volatility.

Adaptive approaches appear to have an edge on predictive ones when it comes to both knowledge complexity and volatility, including the need to learn as one goes along, either due to the novelty or uniqueness of the technical solution or due to lack of sufficient knowledge at start. Their lightweight processes made of fast and frequent cycles with retrospective reviews and frequent stakeholder validation to learn lessons and make adjustments from one cycle to the next, help maintain problem solving alignment with changing needs and requirements, and develop a common understanding, clarify meaning and reduce uncertainty around goals, as stakeholders are required to agree priorities at each cycle, and to validate both assumptions and outcomes quickly and often. With a contained scope in each cycle, they are also effective in dealing with technical volatility, reducing the risk of developing obsolete solutions: this may explain why adaptive methodologies are currently favoured in software development.

Fast and frequent cycles driven by high performing teams also support the process of learning in the case of knowledge complexity or novel solutions, with the team quickly coming to terms with new or complex knowledge, while relying on verbal communication and tacit knowledge, and concentrating resources in each cycle to speed up the process of delivery to time critical goals.

When it comes to technical complexity, controls in predictive approaches include detailed up-front planning, minimising dependences between work packages and robust change control used to avoid scope creep. Moreover, formal risk management practices and the establishment of quality gates between phases, in which key stakeholders formally approve the deliverables of the previous phase, ensure that risk is not carried forward from one phase to the next. On the other hand, controls in predictive approaches are much less specific, relying mainly on standard decomposition into adaptive development cycles performed by a high performance team.

Some controls are methodologically neutral: for instance, prototyping novel solutions can equally apply in predictive and adaptive approaches, as does the adoption of tried-and-tested solutions or establishing a single source of truth.

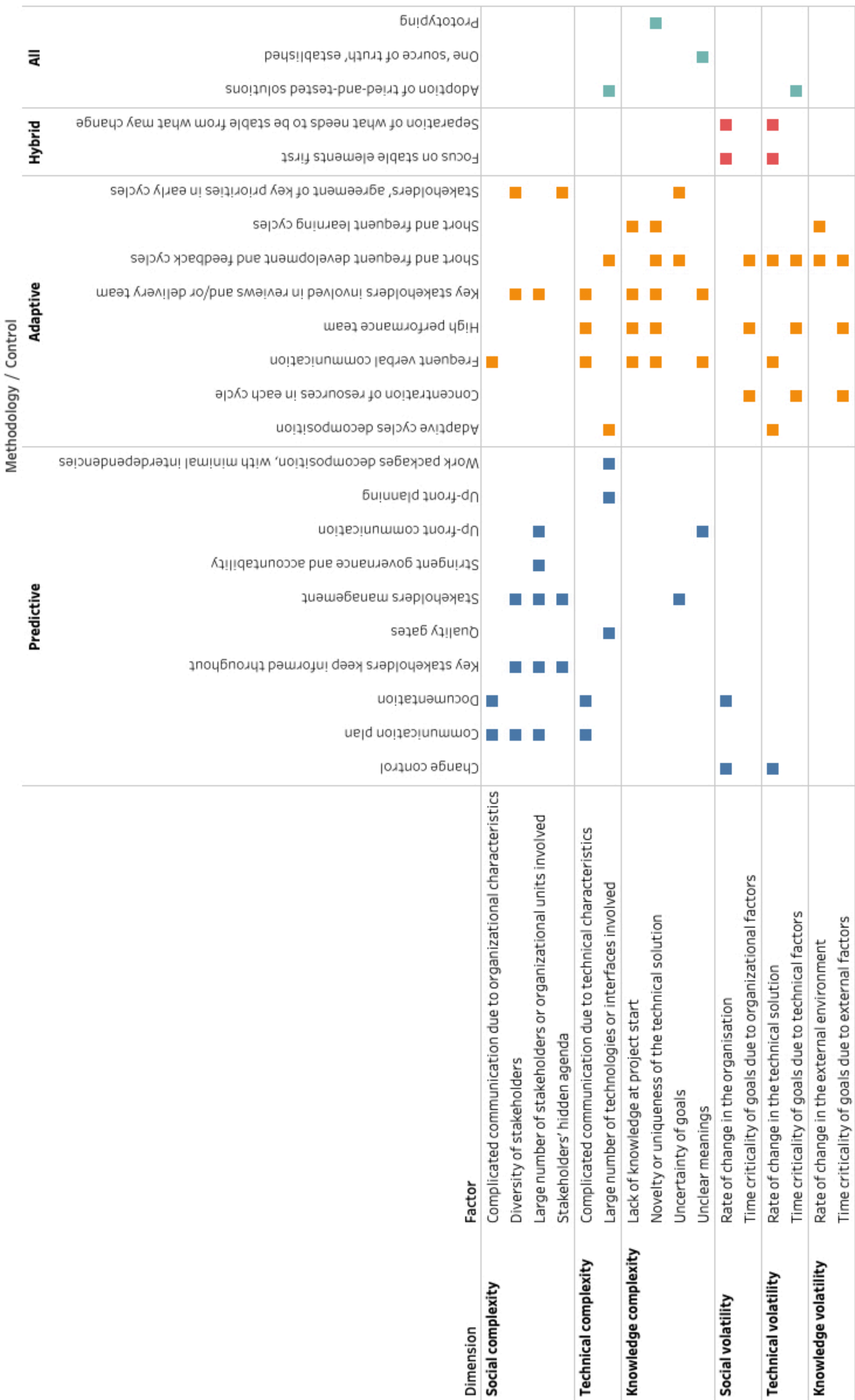

Figure 5: Mapping between factors and controls: for each factor, a selection of controls is provided, indexed by its associated methodology

On the other hand, some controls are only meaningful in projects when a hybrid approach is assumed, like separating stable from variable elements of the project.

5 Conclusion

The last decade has seen an increase in *ad-hoc* hybrid PM approaches, combining elements of predictive and adaptive methodologies, better to deal with today's organisational problems. Better methodological support for hybridisation is still needed, as acknowledged both in the literature and by practitioners participating in our study, and this is the focus of our research. As a first step, in this paper we have explored the extent in which complexity and volatility dimensions of organisational problems can inform hybridisation on a project basis.

Both survey and interview findings point to a high adoption of hybrid approaches in the presence of complexity and volatility, which is in alignment with trends acknowledged in the literature and discussed in Section 1.1. Moreover, they confirm that the practice of mixing approaches still remains ad-hoc, highly reliant on the project manager's expertise, with a common way to integrate them being the embedding of adaptive components within an overarching predictive approach. This appears to be the case not just in software development projects but more generally, although it is true that software projects were prominent in our sample and there was a tendency to apply adaptive practices to software-related project elements.

While our focus was on complexity and volatility, not all PM methodological choices are motivated by them. Our findings confirm that organisational culture/management preferences, alongside external requirements, remain the most influential factor in the adoption of predictive methodologies, which is consistent with previous studies (Theocharis et al., 2015; West et al., 2011), and also influence the way hybrid approaches are currently applied, where we see a prominence of the predictive element. Also, team expertise appears to have a bearing on all choices of methodology. Generally, a mismatch between methodological choice and both organisational culture and project team expertise is seen as a source of project risk, so that some practitioners appear to take the pragmatic stand to adapt the former to the latter rather, regardless of problem characteristics.

The complexity and volatility factors identified in the literature and used as survey prompts and in interviews were recognised by all practitioners as having a bearing in their choice of PM methodology, and only few new factors were added, related to the variability of project scope, budget and schedule, and to the overall level of risk to the organisation or its customers. These additions, although not explicitly related to complexity and volatility, still provide an interesting insight into possible heuristics for setting up hybrid projects, and remain relevant as consideration of complexity and volatility could still be related to each of them: for instance, social complexity is likely to lead to a variable scope, hence needing an adaptive approach.

By synthesising all findings, we were able to generate an initial mapping between volatility and complexity dimensions and PM controls. This mapping has, of course, its limitations, partially due to the level of subjective interpretation which was required in its synthesis, which poses ontological questions, and the relatively small sample of practitioners ($n = 31$) who have taken part in the study, although triangulation with findings from the literature has provided some mitigation against the latter. Nevertheless, we are investigating whether it can form the basis for a more systematic approach to developing hybrid PM practices on a project by project basis. Of particular interest is to develop an understanding of how the different dimensions interact: for instance, while technical complexity may well be better served by predictive approaches, if accompanied by knowledge complexity then the project will require a mix of predictive and adaptive controls and identifying systematic ways to do so effectively would be most beneficial.

Such a systematisation and further refinement of the proposed mapping are the focus of ongoing research. To this end, we are currently embedding PM processes and practices into an existing framework for organisational problem solving, called Problem Oriented Engineering (POE, Hall and Rapanotti (2017)), which will provide the theoretical basis for our novel approach.

Acknowledgements

We thank all survey and interview participants for their insightful comments and contribution to our research.

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